Cycle Time Reduction of a Garment Manufacturing Company Using Simulation Technique

Siti Anisah Atan @ Yaakub, Rohaizan Ramlan, Tan Geok Foong

Faculty of Technology Management and Business
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja Batu Pahat Johor
Malaysia

anisah@uthm.edu.my, rohaizan@uthm.edu.my

ABSTRACT

Cycle time is the key to competitiveness of a firm as it affects both price and delivery schedule. This study aims to model and simulate a garment manufacturer current production line and to propose improvement in order to reduce cycle time and increase output quantity. In the time being, this manufacturer is implementing overtime in order to meet the missed order. However, it still could not meet the requested order. The data needed to simulate the current production line is entered into the ProModel simulation software to analyse the real source for the problem. A solution had been proposed to improve the current situation. From the result, cycle time had been reduced. Reducing the cycle time means more output could be produced to meet the demand. This is very important for the related manufacturer to take note in order to increase their productivity as long as there is no restricting factor.

Keywords: cycle time, garments, modelling, simulation

INTRODUCTION

The shift in policy from import substitution to export oriented industrialization had contributed to the growth of Malaysian textile and apparel industry. In 2011, exports of the industry worth RM10.81 billion and it ranked 9th and accounting for 2.3 per cent share of Malaysia's exports of total manufactured goods (http://www.matrade.gov.my/..). USA, Japan, Turkey, Indonesia and China are top 5 export destinations for Malaysia's textiles and apparels.

Malaysian textile and apparel industry is composed of 2 main sectors. Upstream is the first sector which involves fiber, yarn, fabrics and wet processing activities while the second one is downstream which involves made up garments, textile products (home textile) and accessories.

In order to remain competitive and relevant, Malaysian textile and apparel manufacturers are striving to increase productivity through flexible, automated manufacturing systems; R&D investments; and increasing the technical competency of its employees (http://www.textileworldasia.com/..). In addition, Malaysian companies are collaborating with foreign investors as well as marketing its homegrown brands locally and abroad.

Based on previous study, garment manufacturing comprises a variety of product categories, materials and styling, and complex design (Guner and Unal, 2008; Kursun and Kalaoglu, 2009; Unal et al., 2009; Naresh, P, 2011). Such complexities of manipulating flexible materials and dealing with constantly changing styles limit the degree of automation for the production system. Therefore, labour productivity and making production flexible are industry primary concern.

Harrell et al. (2004), stated that, cycle time is the key to competitiveness of a firm as it affects both price and delivery schedule. Cycle time reduction is strongly correlated with high first pass yield, high throughput times, low variability in process times, low WIP and subsequently cost. Therefore, this study focuses on the cycle time of the garment manufacturer.

Based on the interview with the manufacturer's operational manager, the problem arose due to high lead time to complete the order. The current production line capacity cannot meet the ordered quantity on time even when the production running overtime. Besides, the manufacturer is absent of effective tool in predicting complex scenario of production that relies heavily on human labor. Thus, this study aims to model and simulate the production line and to propose improvement in order to reduce cycle time and increase output quantity.

BACKGROUND OF STUDY

This study was conducted in a garment manufacturing company producing short and long sleeves t-shirt and pants. It only focus on the order of a short sleeve t-shirt. This company supplies their products to high end international brands such as Nike, Oshkosh, The William Carter's and many more under a contract manufacturing arrangement. All garments produced by this company are exported to oversea market like US, Canada, Brazil, Belgium, and Mexico. It consists of 641 workers, 303 are locals and others are foreigner.

The factory operates 6 days a week starting 8.00 am to 5.30 pm from Monday to Friday and till 12.30 pm on Saturday. It means working hour is 8 hour and 45 minutes from Monday to Friday and 4 hour and 15 minutes on Saturday.

In general, there are 6 main sections in this company (figure 1). Raw materials in the form of fabrics rolls are supplied by nearby textiles company and sent for quality checking. If the quality of the fabrics passes the standard, they will be sent to storage and wait for cutting processes. After cutting processes, the fabrics that need for printing will be sent to "heat seal" process before being matched with other fabric components in "kitting" section. Then matching components will go through sewing and become a complete garment. Complete garments are then going for ironing and then packaging. The garments will be kept in storage before delivery to customer.

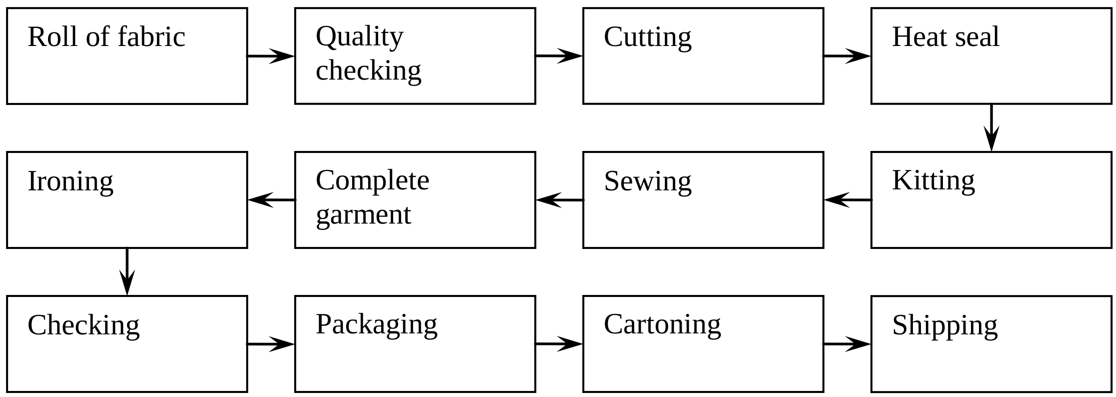


Figure 1: Process flow of studied garment company

LITERATURE REVIEW

Several literatures have been reviewed to gain some idea about the studies in the garment industries and the usage of simulation techniques to analyze operational performance. It is noted that line balancing problems in sewing department is most popular operational issue in apparel or garment industry (Guner and Unal, 2008; Kursun and Kalaoglu, 2009; Unal et al., 2009; Chen et al., 2012). Line balancing in garment industry deals with allocating the resources such as workers and machinery to the assembly line so that the precedence relation are satisfied and the sum of task at any workstation does not exceed cycle time. Simulation has been a preferred tool to evaluate the performance of garment production line as it has the ability to model dynamic and stochastic nature of production systems. It enables the researcher to gain a critical insight into the performance of a manufacturing company.

Naresh (2011) reported that, since sewing department involves tedious manual labor, the process often resulted in a high cycle time and low yields, sewing department contribute a lot of problem in garment manufacturing company. There are lots of different operations done manually and sewing operations needs high skill as well as quality work, especially when handling the difficulty associated with repairing of products sewed with wrong specifications.

Meanwhile, based on Chandra (2005), cycle time is one of the challenges in textile and apparel industry. Cycle time reduction is strongly correlated with high first pass yield, high throughput times, low variability in process times, low WIP and consequently cost. Hence, cycle time is the key to competitiveness of a firm (Harrell et al., 2004).

At the same time, Harrell et al. (2004) mentioned that, with recent advances in computing and software technology, simulation tools are now available to help meet the challenge of quickly designing and implementing complex manufacturing systems that are capable of meeting growing demands for quality, delivery, affordability, and service.

METHODOLOGY

The simulation model of the garment manufacturer was built using ProModel version 7.0 simulation software. The production of the short sleeve t-shirt consists of several different operations (figure 1). The simulation model consists of 4 elements: locations, entity, arrival and processing.

Locations represent fixed places in the company where operations take place. Entity is the thing that being processed in the model. In this model, 3 entities were defined: roll of fabric, t-shirt, and cartoon. A roll of fabric can produce 960 t-shirts and 12 t-shirts are packed together in a carton. Arrival is the mechanism for defining how the entity or entities enter the system. In this model, 19 rolls of fabrics came to the company to be processed to produce 18240 t-shirts or 1520 cartons as ordered by the customer. Processing describes the operations that take place at a location, such as the amount of time of an entity spends there. About 150 data of each operation are obtained using time study techniques. They were key in into statistical software Stat::fit for distribution fitting.

Operations	Fitted distribution
Quality checking (in minute)	Inverse Weibull (15.0, 2.4, 0.261)
Cutting (in minute)	Uniform (201,300)
Heat Seal (in second)	Beta (10.0, 45.0, 4.72, 6.17)
Kitting (in second)	Beta (18.0, 101.0, 1.47, 1.73)
Sewing (in second)	Triangular (6.0, 21.7, 9.14)
Ironing (in second)	Pearson 6 (42.0, 143.0, 1.54, 5.52)
Checking (in second)	Beta (18.0, 78.0, 0.995, 1.67)
Packing (in second)	Beta (45.0, 169.0, 1.49, 4.0)
Cartoning (in second)	Johnson SB (15.0, 17.3, 0.184,0.994)

Table 1: Fitted distribution for each operations data

In order to verify the simulation model, the model was coded and debugged step by step. Trace and animation techniques were used to verify that each program path was correct. The simulation trials were run under a variety of input parameters setting, and checked the model output results for reasonableness. In order to check whether the model is an accurate representation of real system, the validation process is performed based on total output. When the simulation run for certain period of real production, it produced output quantity same as the actual and the simulation is perceived as valid.

Data Analysis

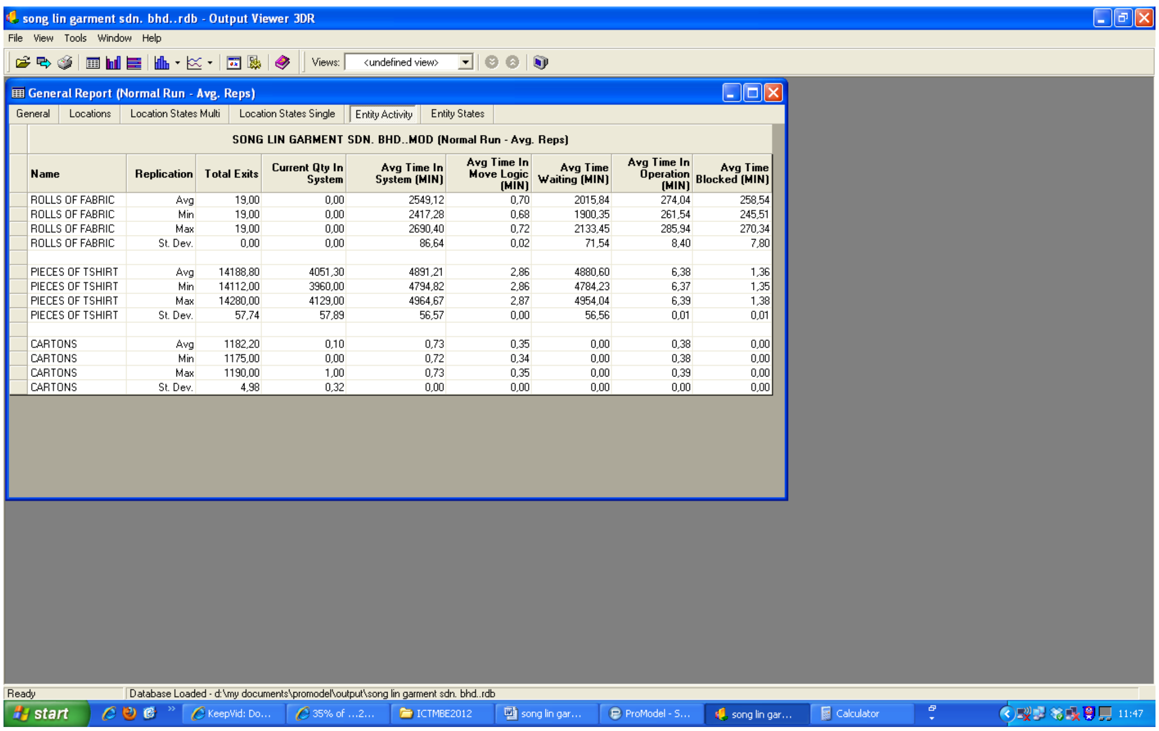
To analyze the results of the simulation, 2 performance measures are considered: throughput and cycle time. The simulation model was run for 225.75 hours and 10 replications. The simulation run time represent total working hours run by the company to complete the order.

As seen in Figure 2 and 3, total output for the t-shirts are 14189 pieces or 1182 cartons as compared to targeted quantity of 18240 pieces or 1520 cartons respectively. This mean that during the period, the company still short of 4051 t-shirt or 338 cartons.

For the cycle time performance, it is the time for the rolls of fabric plus time for the pieces of t-shirt and the cartons whose total is 7441.06 min or 124.02 hr or equivalent to 14.17 working days as shown in Figure 4 and Table 2. The cycle time is very high as compared to total time to produce the ordered quantities which is 225.75 hours.

Analyzed further, only 3.77% of the cycle time is value added and 96.23% non-value added (Table 3). This means that performance of the garment company is very terrible. Almost all the time the entities are spent as work –in process waiting in queue.

In order to improve the current situation of the company, it is suggested that the company to add their current production capacity. The suggestion is based on the simulation results on locations analysis. The result shows that several operations' locations have a very high work in process. These locations are considered necessary to be added their capacity. The recommendation is as shown in the Table 4.



Name	Replication	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Waiting (MIN)	Avg Time In Operation (MIN)	Avg Time Blocked (MIN)
ROLLS OF FABRIC	Avg	19,00	0,00	2549,12	0,70	2015,84	274,04	258,54
ROLLS OF FABRIC	Min	19,00	0,00	2417,28	0,68	1900,35	261,54	245,51
ROLLS OF FABRIC	Max	19,00	0,00	2690,40	0,72	2133,45	285,94	270,34
ROLLS OF FABRIC	St. Dev.	0,00	0,00	86,64	0,02	71,54	8,40	7,80
PIECES OF TSHIRT	Avg	14188,80	4051,30	4891,21	2,86	4880,60	6,38	1,36
PIECES OF TSHIRT	Min	14112,00	3960,00	4794,82	2,86	4784,23	6,37	1,35
PIECES OF TSHIRT	Max	14280,00	4129,00	4964,67	2,87	4954,04	6,39	1,38
PIECES OF TSHIRT	St. Dev.	57,74	57,89	56,57	0,00	56,56	0,01	0,01
CARTONS	Avg	1182,20	0,10	0,73	0,35	0,00	0,38	0,00
CARTONS	Min	1175,00	0,00	0,72	0,34	0,00	0,38	0,00
CARTONS	Max	1190,00	1,00	0,73	0,35	0,00	0,39	0,00
CARTONS	St. Dev.	4,98	0,32	0,00	0,00	0,00	0,00	0,00

Figure 2: Simulation result

Entity	Cycle time
Rolls of fabric	2549.12 min ~ 42.49 hr
Pieces of t-shirt	4891.21 min ~ 81.52 hr
Cartons	0.73 min ~ 0.01 hr
Total cycle time	7441.06 min ~ 124.02 hr ~ 14.17 working days

Table 2: Total cycle time

Entity	Cycle time components(min)			
	Value added	Non-value added		
	Ave time in operations	Average time waiting	Average time blocked	Average time moving
Rolls of fabric	274.04	2015.84	258.54	0.70
Pieces of t-shirts	6.38	4880.60	1.36	2.86
Cartons	0.38	0.00	0.00	0.35
Total	280.80	6896.44	259.90	3.91
%	3.77%	96.23%		

Table 3: Components of cycle time

Operations locations	Current capacity	Recommended capacity
Cutting	1	2
Kitting	1	4
Heat Seal	3	5
Ironing	2	6
Packing	4	6
Cartoning	1	2

Table 4: Garment company current capacity versus recommended capacity

CONCLUSION AND DISCUSSION

The company should consider alternative solutions that can reduce cycle time which lead to higher productivity. As example, cycle time can be shortened by reducing activity times that contribute to flow time such as setup, move operation, and inspection time. It also can be reduced by decreasing work-in-process or average number of entities in the system. Since over 80% of cycle time is often spent waiting in storage or queues, elimination of buffers tends to produce the greatest reduction in cycle time (Harrell et al., 2004).

Performance measure	Current capacity	Recommended capacity	% increase
Total output(t-shirt)	14189	18229	28.47 % increase
Total output(cartons)	1182	1519	28.51% increase
Cycle time	7441.06 min ~ 124.02 hr ~ 14.17 working days	2567.93 min ~ 42.8 hrs ~ 4.89 working days	65.45% reduce

Table 5: Comparison of total output and cycle time for current capacity versus recommended capacity

If production runs within the same period as the current production, the recommended capacity will increase the total output about 28% and reduce the cycle time almost 65% as shown in Table 5 and it means that the required order by customer can be fulfilled.

Nowadays, with the increasing competition, garment companies must respond rapidly to changes in customer demand and improve their productivity. Cycle time is an important performance measure because it relates to high productivity and on time delivery of orders. High production cycle time leads to high cost and affects delivery schedule.

Meanwhile, simulation is a very powerful technique in analyzing complex system such as in garment manufacturing. Simulation offers many advantages such as flexibility, ease of use, and ability to model dynamic and stochastic nature of production systems which enables us to gain a critical insight into the performance of a manufacturing company. In other words, employing simulation as an evaluation tool helps to study the system behavior with respect to machine and worker utilization, throughput, mean work in process levels and mean flow time.

In this study, simulation technique is used to analyze the existing throughput and cycle time of a short sleeve t-shirt production in a garment company. From the simulation result, the bottlenecks that cause high cycle time and low throughput had been identified. Then a recommendation to add more capacity on the location with bottlenecks is made. Simulation on the recommended capacity shows that it can increase existing throughput up to 28% and reduce cycle time at almost 65%. The recommended capacity can help to achieve the production target as set by the company. The only constrain to add more capacity is cost.
The company should consider other solution that can reduce cycle time as well. Cycle time can be shortened by reducing activity times that contribute to flow time such as setup, move operation, and inspection time. It also can be reduced by decreasing work-in-process or average number of entities in the system. Reducing lot size also can reduce production cycle time. Simulation techniques can be employed to evaluate different alternatives solution.

Despite the widespread use of simulation in other manufacturing areas, its use in apparel industry is not very common. It is hoped that this study illustrating the use of simulation in detail for cycle time reduction in a garments company will provide guidance for practitioners and enhance its acceptance in textile industry.

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